Partners Project Title Page
Proposal for a Partners Project

Title: A Cooperative Effort to Develop a Convective Storm Climatology for Northern Arizona

Date: 18 December 2020

Signatures for University
University Name:
Embry-Riddle Aeronautical University
Legal Address:
1 Aerospace Blvd.
Daytona Beach, Florida 32114-3900

Curtis N. James

Principal Investigator
Name: Curtis N. James, Ph.D.
Telephone number: (928) 777-6655
FAX number: (928) 777-3839
Email: Curtis.James@erau.edu
Performance Site Address:
ERAU, Applied Aviation Sciences Dept.
3700 Willow Creek Road
Prescott, Arizona 86301-3720

Jennah Perry Digitally signed by Jennah Perry Date: 2021.01.26 11:04:00 -07'00'

ERAU Applied Aviation Sciences Dept.
Name: Jennah Perry, Ph.D.
Title: Department Chair
Telephone number: (928) 777-3860
FAX number: (928) 777-3839

Nanette Guzman Digitally signed by Nanette Guzman Date: 2021.01.25 11:52:20 -05'00'

University Official (contract sent to)
Name: Nanette Guzman, DBA, CRA
Title: Director, Office of Sponsored Research Administration
Telephone number: (386) 226-6196
FAX number: (386) 226-7695
Email: osra@erau.edu

Signatures for NWS
National Weather Service:
NWS Office: Flagstaff Forecast Office
Address:
49 Hughes Ave., Bellemont, AZ 86015

TAYLOR.ANDREW.A.1365885652 Digitally signed by TAYLOR.ANDREW.A.1365885652 Date: 2021.01.22 08:06:17 -07'00'

Principal Investigator
Name: Andrew Taylor, Ph.D., SOO
Telephone number: (928) 556-9161 x 224
FAX number: (928) 774-3914
Email: andrew.taylor@noaa.gov

KLIMOWSKI.BRIAN.A.1365873131 Digitally signed by KLIMOWSKI.BRIAN.A.1365873131 Date: 2021.01.22 12:38:05 -07'00'

MIC/HIC
Name: Brian Klimowski, Ph.D.
Telephone number: (928) 556-9161 x 222
FAX number: (928) 774-3914

Michael Staudenmaier Jr. Digitally signed by Michael Staudenmaier Jr. Date: 2021.02.09 09:35:26 -07'00'

SSD Chief
Name: Michael Staudenmaier, Ph.D.

COOPER.GRANT.ALEXANDER.1047689399 Digitally signed by COOPER.GRANT.ALEXANDER.1047689399 Date: 2021.02.11 13:07:20 -07'00'

Regional Director
Name: D. Grant Cooper, Ph.D.

SUMMARY OF BUDGET REQUEST:
COMET FUNDS: Year 1 $16,502
NWS FUNDS: FY 21 $0 FY 22 $4,900

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Summary: Northern Arizona is an ideal laboratory for an investigation into deep convection in complex terrain. On an almost daily basis during the North American Monsoon (NAM), thunderstorms tend to initiate over higher elevation locations. Many of these events are isolated pulse storms that become terrain-locked or back-build into light steering flow, producing slow-moving cloudbursts with rain rates exceeding 100 mm h^{-1}. In other cases when the vertical shear is more favorable, the convection becomes organized into multicellular storms or quasi-linear convective systems (QLCSs) that propagate from the higher terrain into the lower and more densely populated desert regions of central and southern Arizona. Northern Arizona thunderstorms are often responsible for severe weather, critical fire weather, and flash flooding of normally dry washes and streams. Some of these events have caused high-impact property damage and loss of life (e.g. Haro and Green 1996, Vandell 2017, Kaplan et al. 2020).

Previous studies have explored various characteristics of the monsoon environment. Mazon et al. (2016) examined ~400 high-impact weather events during an 18-y period. Their work characterized the synoptic flow patterns favoring severe convection in Arizona. Erlingis et al. (2019) analyzed back trajectories from a number of Arizona flash flood events, identifying the main moisture sources, principally the Gulf of California at low levels and the Gulf of Mexico at mid levels. Yang et al. (2019) identified four synoptic flow patterns favoring ~100 flash flood events during the NAM in central Arizona. By tracking individual convective cells, their analysis revealed only a weak dependence of storm intensity and storm size in relation to topography. However, their work focused mainly on the low-lying deserts of central Arizona and included a conglomerate of synoptic flow patterns and convective events, combining both QLCSs and pulse storms. These and other prior studies have not captured the fine-scale influences that pre-condition and initiate convection in complex terrain, specifically in northern Arizona. This gap in our understanding is directly relatable to the difficulty that forecasters have in predicting deep convection and its impacts.

We therefore propose to create a climatology of convective cell tracks, specifically over northern Arizona where thunderstorms are frequent during the NAM. These tracks will include cell initiation points, cell motion and intensity, and dissipation locations as applicable. This dataset will be created using at least 10 years of WSR-88D volumes or Multi-Radar Multi-Sensor data (MRMS; https://mrms.nssl.noaa.gov/). These MRMS data are archived on a Cartesian grid in GRIB2 format (https://mrms.nssl.noaa.gov/) and available in real-time. This dataset incorporates multiple radars and sensors to diagnose the precipitation rate at 5-min temporal and 0.01° (1.11 km) spatial resolution across the continental U.S.

A variety of automatic algorithms have been developed for detecting and tracking convective cells, storing cell centroid location as a function of time. We will first examine the utility of these techniques, especially over the complex terrain of northern Arizona. The operational Storm Cell Identification and Tracking algorithm (SCIT; Johnson et al. 1998), which has been the operational WSR-88D algorithm since 1998, has been used to create a 23-year database of storm tracks (https://www.ncei.noaa.gov/maps/swdi/). These tracks are freely available and easily obtainable in a variety of formats. However, each point along these tracks is rounded to the nearest integer in azimuth (degrees) and range (nautical mile) from each WSR-88D site. Thus, these SCIT archives may not contain sufficient precision to capture the fine-scale influences of topography on convective initiation and propagation, especially at longer range from a given WSR-88D site. Moreover, convective cells may also go undetected in locations obscured from a single radar by terrain shadowing. We will therefore consider the utility of calculating our own convective tracks using the TITAN cell-tracking algorithm (Dixon and Wiener 1993), which was utilized by Yang et al. (2019), or Thunderstorm DATing (Detection and Tracking), a new algorithm available in the PySteps library (Pulliken et al. 2019; https://pysteps.readthedocs.io/en/latest/). Both of these latter algorithms have the capability of operating on a 2-D gridded dataset such as MRMS QPE or CREF data. We anticipate that convective storm tracks created using MRMS data may enable higher-resolution and more spatially consistent convective storm tracks than those created operationally using the SCIT algorithm. This study will therefore be applicable to operational thunderstorm nowcasting, as convective storm tracks are not currently being created and archived using MRMS data. Although NWS forecasters have access to the ProbSevere model (https://cimss.ssec.wisc.edu/severe_conv/probsev.html; Cintineo et al. 2020), a classifier technique that statistically

predicts the occurrence of severe weather using multiple datasets including MRMS, to our knowledge there is no operational convective cell tracking algorithm that uses MRMS data.

In this study, two undergraduate researchers, with oversight from the PIs, will select the most suitable storm tracking technique. The student researchers will then compile at least 10 years of storm tracks for use by ERAU and NWS scientists. Time and funding permitting, these data will also be linked to storm reports, severe radar signatures, and various forecast model/reanalysis gridded data. Thus, a detailed convective climatology in relation to complex terrain of northern Arizona may be achieved. This climatology will be made available to operational forecasters for improving mesoscale forecasting of deep and extreme rainfall producing orographic convection.

Objectives:

1) Examine the feasibility of using MRMS data for creating convective cell tracks. If possible, National Lightning Detection Network (NLDN) data may also be used to improve cell tracking performance.

2) Archive at least a 10-year storm track dataset for an area covering at least the northern half of Arizona.

3) Create a convective climatology for northern Arizona in relation to the complex terrain, in terms of thunderstorm frequency, triggering frequency, dissipation frequency, and storm propagation.

4) If time and funding allow, associate storm track data with other observables (storm reports, meso, tvs and hail signatures, and a number of data in the gridded model fields) to gain insight into the meso-gamma scale predictability of thunderstorm tracks and impacts in relation to terrain influences.

Tasks:

1) Create sample storm tracks for 5 different convective events over northern Arizona with MRMS data (using TITAN, Thunderstorm DATing, or both). We may also be able to utilize the cell tracking tools provided by the WDSS II software (http://wdssii.org/algdoc.shtml) to achieve this objective. We also may be able to incorporate NLDN data.

2) Compare the MRMS tracks with archived SCIT tracks and determine the feasibility of creating our own storm track database.

3) Assemble a 10-year archive of storm tracks using the method that we consider to be the most accurate/reliable. These tracks must cover at least the northern half of Arizona, but may include the entire continental U.S. The data will be stored on the 20-TB RAID drive in the Meteorology Lab at Embry-Riddle Aeronautical University.

4) Download hail, meso, tvs, lsr, and warning shapefiles for the same period from NOAA’s Severe Weather Data Inventory (https://www.ncei.noaa.gov/maps/swdi/)

5) Using ArcGIS, calculate the following, and add these data to the attribute table for each cell at each time step:

a. Cell motion (speed, direction) as calculated using a backward difference from previous cell location

b. Cell initiation and dissipation locations (for all tracks, record the initial position and, if it lasts at least two time steps, the final position of each cell)

c. Record severe weather attributes: whether a meso was detected; tvs information (max shear, maxdv); max hail size; plus any relevant warnings or lsr data

d. Terrain elevation

e. Terrain slope and azimuth

6) Perform a basic convective climatology for at least northern Arizona. Special emphasis will be placed on the two main population centers in northern AZ (i.e. Prescott and Flagstaff). Terrain influences in both of these areas are significant and loosely understood, but it would be helpful to the forecasters to visualize these influences geographically. For instance, where is the most common initial storm development affecting the Flagstaff and Prescott areas? In particular, the following analyses will be performed:

a. Convective cell frequency during the NAM (heat map) in relation to the complex terrain

b. Frequency map of storm initiation in relation to the complex terrain

c. Frequency map of storm dissipation in relation to the complex terrain

d. Mean storm propagation direction/speed as a function of location

7) As time and funding allow, add relevant "predictor" data from reanalysis grids or operational model grids at each time step along a storm's track. These attributes may include the following variables, interpolated at the time/location of each cell.

a. CAPE (SB, ML, and/or MUCAPE)

b. CIN (SB, ML, and/or MUCIN)

c. LCL-LFC averaged wind speed/direction (mean wind)

d. BL-3km SRH

e. BL-3 km AGL bulk shear magnitude/direction (LL shear)

f. BL-6 km AGL bulk shear magnitude/direction (deep shear)

g. BRN

h. 500-mb wind speed/direction (upper-level wind)

i. 700-mb wind speed/direction (mid-level wind)

j. 850-mb wind speed/direction (low-level wind)

k. surface wind speed/direction

l. 700-mb temperature advection

m. Surface dew point temperatures

n. Precipitable water

o. Integrated moisture flux

p. Surface (10-m) divergence

q. Surface (10-m) vorticity

r. Low-mid-level (700-600 hPa) vertical velocity

s. Planetary boundary layer depth and turbulence kinetic energy

8. As time and funding allow, perform and conceptualize a more detailed climatology in relation to the complex terrain in northern Arizona, by subdividing our track data based on other model predictors:

a. Convective cell frequency map superposed with population density
b. Convective cell frequency map as a function of CAPE
c. Convective cell frequency map as a function of CIN
d. Convective cell propagation as a function of mean wind
e. Convective cell propagation as a function of low-level wind
f. Convective cell propagation as a function of low-level shear
g. Convective cell frequency maps as a function of mean wind direction/speed
h. Convective cell triggering/dissipation frequency maps as a function of mean wind direction/speed
i. Convective cell triggering/dissipation frequency maps as a function of wind at different levels
j. Convective cell triggering/dissipation frequency maps as a function of low-level shear
k. Convective cell frequency in relation to terrain height, slope and azimuth
l. Convective cell frequency in relation to planetary boundary layer kinematic and thermodynamic characteristics

9) Document the results with an NWS Technical Memorandum and/or refereed journal manuscript as well as an AMS and/or NWA conference presentation performed by the PIs and Co-investigators.

Schedule:

Task 1: February – March 2021.

Task 2: February – March 2021.

Task 3: March – April 2021.

Task 4: April – May 2021.

Task 5: May – June 2021.

Task 6: June – July 2021.

Task 7: July 2021 – September 2021.

Task 8: September 2021 – October 2021.

Task 9: October – December 2021.

Contributors (PIs):

- Curtis N. James, Ph.D. (2-page CV attached)

  Curtis James is a Professor of Meteorology and former Department Chair of Applied Aviation Sciences at Embry-Riddle Aeronautical University (ERAU) in Prescott, Arizona. He has taught courses in beginning meteorology, aviation weather, thunderstorms, satellite and radar imagery interpretation, atmospheric physics, mountain meteorology, tropical meteorology and weather forecasting techniques for over 22 years. He has also served as Director of ERAU's Undergraduate Research Institute and as faculty representative to the university's Board of Trustees. He participates in ERAU's Study Abroad program, offering alternating summer programs each year in Switzerland and Brazil.

  He earned a Ph.D. in Atmospheric Sciences from the University of Washington (2004) and participated in the Mesoscale Alpine Programme (MAP; 1999), an international field research project in the European Alps. His research specialties include radar, mesoscale, and mountain meteorology. He earned his B.S. in Atmospheric Science from the University of Arizona (1995), during which time he gained two years of operational experience as a student intern with the National Weather Service Forecast Office in Tucson, Arizona (1993-1995).

  Dr. James is a native of Arizona where he currently resides with his wife and children. He is active in his community, having served as President of the Prescott SciTechFest Advisory Committee and as President of the local chapter of the Phi Kappa Phi Honor Society. On his spare time, he enjoys weather watching, backpacking, camping, fishing, mountain biking, acting, and music.

- Andrew Taylor, Ph.D. (2-page CV attached)

  Andrew Taylor is the Science and Operations Officer (SOO) at the National Weather Service (NWS) forecast office in Flagstaff, Arizona, a position he has held since 2011. He has been employed full-time with the NWS since 2007, in addition to participating in the NWS Student Career Experience Program (SCEP) from 1999-2001. Dr. Taylor is currently part of a team of SOOs working with the NWS Office of Organizational Excellence (OOE) to develop resources detailing the relevance of culture to the SOO program. He has also recently served on a team revising the NWS Meteorologist Development Plan to align it more closely with expected GS 5-12 competencies and to make the plan easier to use. Outside of the NWS, Dr. Taylor currently serves on the Embry-Riddle Aeronautical University Industry Advisory Board (IAB), helping to advise faculty on curriculum changes that will better prepare students for future employment.

Summary of Contributions:

- One-two undergraduate meteorology students will be hired to perform Tasks 1-8.

- PI James and PI Taylor will supervise the 1-2 undergraduate research assistants working on this project and will oversee the creation of the storm tracks with TITAN and/or Thunderstorm DATing algorithms using MRMS data (Task 1). PIs James and Taylor will select the cases for testing MRMS-derived tracks.
- PI James and PI Taylor will oversee the comparison of MRMS-derived and SCIT tracks and the decision of which tracks to archive (Task 2).
- PI James will oversee the creation of the 10-year storm track archive on the ERAU RAID storage device Task 3-4).
- Co-I Schroeder will oversee the creation of the convective climatology for Arizona using ArcGIS (Tasks 5-8).
- Co-I Sinclair will assist students with adding relevant "predictor" data to the attribute tables for convective tracks (Task 7).
- Co-I Kaplan will assist PIs with the dynamical interpretation and writing of the results (Task 9).

References:

Cintineo, J. L., M. J. Pavolonis, J. M. Sieglaff, L. Cronce, and J. Brunner, 2020: NOAA ProbSevere v2.0–ProbHail, ProbWind, and ProbTor. *Wea. Forecasting,* **35,** 1523–1543, https://doi.org/10.1175/WAF-D-19-0242.1.

Dixon, M., and G. Wiener, 1993: TITAN: Thunderstorm Identification, Tracking, Analysis, and Nowcasting—A radar-based methodology. *J. Atmos. Oceanic Technol.,* **10,** 785–797, https://doi.org/10.1175/1520-0426(1993)010<0785:TTITAA>2.0.CO;2.

Erlingis, J. M., J. J. Gourley, and J. B. Basara, 2019: Diagnosing Moisture Sources for Flash Floods in the United States. Part I: Kinematic Trajectories. *J. Hydrometeor.,* **20,** 1495–1509, https://doi.org/10.1175/JHM-D-18-0119.1.

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Johnson, J.T., Pamela L. MacKeen, Arthur Witt, E. DeWayne Mitchell, Gregory J. Stumpf, Michael D. Eilts, and Kevin W. Thomas, 1998: The Storm Cell Identification and Tracking Algorithm: An Enhanced WSR-88D Algorithm. *Wea. Forecasting*, **13,** 263- 276.

Kaplan, M. L., C. N. James, A. Taylor, M. R. Sinclair, Y-L. Lin, J. Riley, and J. Ising, 2020: Multi-Scale Dynamics of the Winds that Influenced the Yarnell Hill Fire Part I: Observational Analyses of Downscale Organization. Submitted to *J. Geophys. Res. Atmos.*

Mazon, J. J., C. L. Castro, D. K. Adams, H. Chang, C. M. Carrillo, and J. J. Brost, 2016: Objective Climatological Analysis of Extreme Weather Events in Arizona during the North American Monsoon. J. *Appl. Meteor. Climatol.,* **55,** 2431–2450, https://doi.org/10.1175/JAMC-D-16-0075.1.

Pulkkinen, S., D. Nerini, A. Perez Hortal, C. Velasco-Forero, U. Germann, A. Seed, and L. Foresti, 2019: Pysteps: an open-source Python library for probabilistic precipitation nowcasting (v1.0). *Geosci. Model Dev.,* **12 (10),** 4185–4219, https://doi.org/10.5194/gmd-12-4185-2019.

Smith, T. M., and Coauthors, 2016: Multi-Radar Multi-Sensor (MRMS) severe weather and aviation products: Initial operating capabilities. *Bull. Amer. Meteorol. Soc.,* **97,** 1617-1630, https://doi.org/10.1175/BAMS-D-14-00173.1.

Vandell, P., 2017: The Payson flash flood: How did this happen? *The Republic*, 17 July, https://www.azcentral.com/story/news/local/arizona/2017/07/18/payson-flash-flood-wildfire-scars/486545001/.

Yang, L., J. Smith, M. L. Baeck, and E. Morin, 2019: Flash Flooding in Arid/Semiarid Regions: Climatological Analyses of Flood-Producing Storms in Central Arizona during the North American Monsoon. *J. Hydrometeor.*, **20,** 1449–1471, https://doi.org/10.1175/JHM-D-19-0016.1.

Budget:

	COMET Funds	NWS Contributions
University Senior Personnel		
1. Curtis James, Ph.D.	**0**	**NA**
2. Ronny Schroeder, Ph.D.	**0**	**NA**
3. Michael Kaplan, Ph.D.	**0**	
Other University Personnel		
1. Undergraduate research assistants (500 h)	**$9,000**	**NA**
		NA
Fringe Benefits on University Personnel	**0**	**NA**
Total Salaries + Fringe Benefits	**$9,000**	**NA**
NWS Personnel		
FY2021	**NA**	100 h
FY2022		50 h
Travel		
1. Research Trips	**0**	
2. Conference Trips	**$2,500**	$2,500 (FY 22)
3. Other	**0**	
Total Travel	**$2,500**	$2,500 (FY 22)
Other Direct Costs		
1. Materials & Supplies	**0**	**NA**
2. Publication Costs (put in the NWS column if a co-author will be an NWS employee)		$2,400 (FY 22)
3. Other Data	**0**	
4. NWS Computers & Related Hardware	**NA**	
5. Other (specify)	**0**	
Total Other Direct Costs		
Indirect Costs		**NA**
1. Indirect Cost Rate	**$ 0.435**	
2. Applied to which items?	**Wages & Travel**	
Total Indirect Costs	**$5,002**	**NA**
Total Costs (Direct + Indirect)	$16,502	$4,900

Budget Details
A Cooperative Effort to Develop a Convective Storm Climatology for Northern Arizona
PI: Dr. Curtis James

Direct Labor	**Year 1**	**Year 2**	**Year 3**	**Total**
Salaries - Stipends - Wages				
PI: Name (x% AY effort)	$ -	$ -	$ -	$ -
PI: Name summer effort (x months)	$ -	$ -	$ -	$ -
UGR Student Hourly Wages	$ 9,000	$ -	$ -	$ 9,000
	$ 9,000	$ -	$ -	$ 9,000
Direct Costs				
Materials & Supplies	$ -	$ -	$ -	$ -
Travel	$ 2,500	$ -	$ -	$ 2,500
PhD Student Tuition Waiver	$ -	$ -	$ -	$ -
Sub-total Direct Costs	**$ 2,500**	**$ -**	**$ -**	**$ 2,500**
Total Direct Labor and Direct Costs	**$ 11,500**	**$ -**	**$ -**	**$ 11,500**
Modified Total Direct Costs Base	**$ 11,500**	**$ -**	**$ -**	**$ 11,500**
Indirect Costs				
43.5% Modified Total Direct Cost	**$ 5,002**	**$ -**	**$ -**	**$ 5,002**
TOTAL BUDGET REQUEST	**$ 16,502**	**$ -**	**$ -**	**$ 16,502**

Budget Justification

TBD Undergraduate Student(s): $9,000

To be determined one/two undergraduate students will work 10hrs. per week during the spring 2021 academic period, and 20hrs. per week during summer 2021 sessions at $12.50hr. on the project. Dr. James will be responsible for student oversight and oversee the creation of the storm tracks with TITAN and/or Thunderstorm DATing algorithms using MRMS data.

Travel Costs: $2,500

Funds are requested for one trip during the project period. All lodging and per diem meal rates are based on maximum rates established by ERAU's travel policy APPM 2.3.8, which sets rates at or below those established by the GSA and Department of State. Airfare is estimated using quotes from flight aggregators for domestic economy class flights.

The trip from Phoenix, AZ to [placeholder city] Las Vegas, NV is for PI and two others to attend the National Weather Service Conference in January 2022. Per trip costs are estimated at: Airfare at $187, lodging at $120 x 3 nights, per diem at $61 x 2 days, and $20 x 2 days, ground transportation at destination airport (uber, taxi, shuttle) $38.33, shuttle from Prescott to Phoenix airport per person roundtrip at $86. Miscellaneous costs [e.g., luggage] $0.

Facilities and Administrative Costs: $5,002

Facilities and administrative costs (F&A, indirect costs) are calculated on modified total direct costs using F&A rates approved by the US Department of Health and Human Services. The current Federally approved Rate Agreement is dated 6/30/2022. F&A is applied to allowable direct costs minus the following: capital equipment (unit cost is $5,000 or above), tuition and fees, participant support, scholarships, fellowships, rental of off-site facilities, and the portion of each subrecipient award that exceeds $25,000.

The approved F&A rate used for this proposal is 43.5%.

Actions Before Proposal is Submitted to COMET	YES	NO	DATE
1. Did NWS office staff and university staff meet to discuss and form outline and scope of project?	X		12/7/2020
2. Did NWS office consult Scientific Services Division (SSD) staff?	X		12/21/2020
3. Was Statement of Work and budget formulated as a team effort between university and NWS staffs?	X		1/5/2021
4. Was proposal submitted to SSD for review?	X		1/27/2021
5. Did SSD forward copies of proposals dealing with WSR-88D data to Radar Operations Center (ROC), Applications Branch Chief for review?	X		1/27/2021
6. Did SSD forward copies of proposals dealing with hydrometeorology to the Senior Scientist of National Water Center (under NWS Office of Water Prediction) for review?	X		1/27/21
7. Did SSD review the data request for project to ensure its scope and criticality for proposal?	X		
8. Is all data for the project being ordered by NWS offices through the National Center for Environmental Information (NCEI) (ncei.info@noaa.gov) free of charge?	X		1/19/2021
9. Does budget include publication charges and travel costs for NWS employees to present results at scientific conferences?	X		1/19/2021
10.Does budget separate NWS costs into fiscal year costs and university costs into calendar year costs?	X		1/19/2021
11.Does proposal include a separate justification for university hardware purchases which are usually not funded by the COMET Outreach Program?		X	n/a
12. Have the following people signed off on the proposal cover sheet: - MIC/HIC? - SSD Chief? - Regional Director?	X		2/9/2021
13. Is a letter of endorsement signed by regional director attached?	X		2/9/2021

Actions after Endorsement by NWS	**YES**	**NO**	**DATE**
1. University submits proposal to the COMET Program.	X		2/23/2021
2. Proposal acknowledgment letter sent by the COMET Program to submitting university with copies to SSDs and NWS office.			
3. COMET review of proposal (internal review for Partners Project proposals and formal review for Cooperative Project proposals).			
4. The COMET Program sends acceptance, rejection, or modification letters to university with copies to SSD, NWS office, and NWS Office of Science and Technology Integration (OSTI).			
5. The COMET Program allocates funds for university.			
6. OSTI obligates funds for NWS offices.			
7. SSD/NWS office orders data from NCEI.			
8. NWS office or SSD calls OSTI for accounting code for expenses.			
9. NWS office sends copies of all travel vouchers and expense records to OSTI.			
10. NWS office or SSD sends copies of publication page charge forms to OSTI.			
11. NWS office keeps SSD informed of progress on the project and any results or benefits derived from the project.			

Curriculum Vitae:

Curtis N. James, Ph.D.

Professor of Meteorology
Department of Applied Aviation Sciences
Embry-Riddle Aeronautical University

(a) Professional Preparation

University of Washington	Seattle, WA	Atmospheric Sciences	Doctor of Philosophy	2004
University of Arizona	Tucson, AZ	Atmospheric Science	Bachelor of Science	1995

(b) Appointments

2015 – present	Professor of Meteorology, Embry-Riddle Aeronautical University
2014 – 2020	Department Chair, Applied Aviation Sciences, Embry-Riddle Aeronautical University
2012 – 2014	Director, Undergraduate Research Institute, Embry-Riddle Aeronautical University
2006 – 2009	Faculty Board of Trustees Representative, Embry-Riddle Aeronautical University
2006 – 2015	Associate Professor of Meteorology, Embry-Riddle Aeronautical University
2000 – 2006	Assistant Professor of Meteorology, Embry-Riddle Aeronautical University
1998 – 1999	Instructor, Northwest Aviation College
1995 – 1999	Lead Teaching Assistant/Research Assistant, University of Washington
1993 – 1995	Student Intern, National Weather Service

(c) Products:

(i) Five Related Products

Feldmann, M., C. N. James, M. Boscacci, D. Leuenberger, M. Gabella, U. Germann, D. Wolfensberger and A. Berne, 2020: R2D2: A region-based recursive Doppler dealiasing algorithm for operational weather radar. *J. Atmos. Oceanic Technol.,* **37,** 2341-2356.

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James, C. N., and R. A. Houze, Jr., 2001: A real-time four-dimensional Doppler dealiasing scheme. J. Atmos. Oceanic Technol., **18,** 1674-1683. *[NOTE: This algorithm has been used as the operational Doppler dealiasing algorithm for the operational MeteoSwiss radar network from 2005 – present and is one of the algorithms in the NCAR RAL Thunderstorm Auto Nowcasting software]*.

Houze, R. A., Jr., C. N. James, and S. Medina, 2001: Radar observations of precipitation and airflow on the Mediterranean side of the Alps: Autumn 1998 and 1999. *Quart. J. Roy. Meteor. Soc.,* **127**, 2537-2558.

(ii) Five Other Significant Products

Panziera, L., C. James, and U. Germann, 2014: Frequent flash floods in southern Switzerland: Why? EGU General Assembly Conf. Abstracts, **16,** 6642.

Panziera, L., C. N. James and U. Germann, 2014: Mesoscale organization and structure of orographic precipitation producing flash floods in southern Switzerland. Extended abstracts, 28th Conf. on Hydrology, Atlanta, GA, Amer. Meteor. Soc.

James, C. N., and R. A. Houze, Jr., 2005: Modification of precipitation by coastal orography in storms crossing northern California. *Mon. Wea. Rev.*, **133,** 3110–3131.

James, C. N., S. R. Brodzik, H. Edmon, R. A. Houze, Jr., and S. E. Yuter, 2000: Radar data processing and visualization over complex terrain. *Wea. Forecasting*, **15,** 327-338.

Chong, M., J.-F. Georgis, O. Bousquet, S. R. Brodzik, C. Burghart, S. Cosma, U. Germann, V. Gouget, R. A. Houze, Jr., C. N. James, S. Prieur, R. Rotunno, F. Roux, J. Vivekanandan, and Z.-X. Zeng, 2000: Real-time wind synthesis from Doppler radar observations during the Mesoscale Alpine Programme. *Bull. Amer. Meteor. Soc.*, **81,** 2953-2962.

(d) Synergistic Activities

- Worked as a Visiting Scientist at MeteoSwiss in Locarno, Switzerland (2005, 2011, 2019)
- Created a new B.S. degree program in Unmanned Aircraft Systems (2015), which currently has 80+ majors and 50+ minors
- Developed and led research-focused study abroad programs for undergraduates in Switzerland and the Amazon Basin (2012, 2013, 2014, 2015, 2017, 2019)
- Chapter officer, and currently President Elect, in the local chapter of the Phi Kappa Phi Honor Society at Embry-Riddle Aeronautical University (2016-present)
- Served as a member of the Faculty Senate Executive Committee at Embry-Riddle Aeronautical University (2006-2009)

Andrew Allen Taylor

Science and Operations Officer
National Weather Service
Weather Forecast Office
Flagstaff, Arizona

Education

University of Oklahoma, Norman, Oklahoma
Doctor of Philosophy, Meteorology 2010

University of Oklahoma, Norman, Oklahoma
Master of Science, Meteorology 2003

University of Utah, Salt Lake City, Utah
Bachelor of Science, Meteorology 2000

Professional Publications

Kaplan, M.L., C.N. James, A. Taylor, M.R. Sinclair, Y.-L. Lin, J. Riley, and J. Ising, 2020: The Multi-Scale Dynamics of the Winds that Influenced the Yarnell Hill Fire Part I: Observational Analyses of Downscale Organization. Submitted to *J. Geophys. Res. Atmos.*

Kuster, C.M., P. Burke, and A.A. Taylor, 2012: An 11-Year Radar-Based Study of Tornadic Thunderstorms over Central Oklahoma. *Electronic J. Severe Storms Meteor.*, **7**(8), 1-18.

Leatham, W.E., P.C. Burke, and A.A. Taylor, 2011: Verifying model forecasts of arctic fronts in advance of winter storms in the southern Plains. Preprints, Tenth Annual Student Conference, Seattle, WA, Amer. Meteor. Soc., S17.

Taylor, A.A., 2010: Ensemble Kalman filter data assimilation in the presence of large model error. Ph.D. dissertation, University of Oklahoma, 125 pp.

Taylor, A.A., and L. M. Leslie, 2005: A single-station approach to Model Output Statistics temperature forecast error assessment. *Wea. Forecasting*, **20**, 1006-1020.

Stensrud, D., L. Leslie, J. Merchant, A. Taylor, C. Godfrey, and R. Bonifaz, 2004: Generation of improved land-surface data for high-resolution numerical weather prediction models. Preprints, 16th Conference on Numerical Weather Prediction, Seattle, WA, Amer. Meteor. Soc., CD-ROM, P1.38.

Relevant Conference Presentations

- Arizona Floodplain Management Association Fall Conference (2017, Flagstaff AZ)
    - *NWS Flagstaff Highline Fire Scar Support Service* * invited presentation
- National Weather Association Annual Meeting (2017, Garden Grove CA)
    - *Successes and Challenges using Ensemble-Based Tools to Forecast and Communicate a High-Impact Cool Season Precipitation Event in Northern Arizona*
- National Weather Association Annual Meeting (2015, Oklahoma City OK)
    - *Toward Improved Consistency of Flash Flood Product Issuance in the Southwestern United States*
- SW Convective Workshop (2015, Phoenix AZ)
    - *Communication and Collaboration Associated with the 28 Feb – 3 Mar 2015 Heavy Precipitation Event in Northern Arizona*
- American Meteorological Society Annual Meeting (2015, Phoenix AZ) and
- National Weather Association Annual Meeting (2014, Salt Lake City UT)
    - *Meteorological Conditions and Decision Support Services Associated with the Yarnell Hill Fire*
- SW Convective Workshop (2014, Phoenix AZ)
    - *Monsoon 2013 in Northern Arizona: Multiple Flash Flood Events and Associated Impacts*

Positions Held

Science and Operations Officer, National Weather Service, Flagstaff, AZ	2011 - present
General Forecaster, National Weather Service, Norman, OK	2008 - 2011
Intern, National Weather Service, Norman, OK	2007 – 2008
Research Assistant, University of Oklahoma, Norman, OK	2001 - 2007

Relevant Team Memberships and Activities

Embry-Riddle Aeronautical University Industry Advisory Board	2018 - present
STI EMC Model Evaluation Group CAM/Hi-Res Model Team	2015 - 2020
Meteorologist Development Plan Team	2019 – 2020
Mentor, NOAA Hollings Scholar Program	2011
Experimental Warning Program, Hazardous Weather Testbed	2010 - 2011
Mentor, National Weather Center REU Program	2010

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
Western Region Headquarters
125 S. State St Rm 1311
Salt Lake City, UT 84138

February, 9 2021

MEMORANDUM FOR: COMET Review Team

FROM: Grant Cooper, Ph.D.
Western Region Director

COOPER.GRANT.ALEXANDER.1047689399
Digitally signed by COOPER.GRANT.ALEXANDER.1047689399
Date: 2021.02.11 13:09:30 -07'00'

SUBJECT: Convective Climatology COMET Proposal

I have reviewed the proposal entitled; **"A Cooperative Effort to Develop a Convective Storm Climatology for Northern Arizona"** submitted by the Embry-Riddle Aeronautical University and WFO Flagstaff.

The proposal includes novel work that would increase our knowledge of convective processes in complex terrain with clear applications to operational meteorologists in Arizona and potential extension to other parts of the West. The project is logical and consistent with the funding requested.

I endorse this proposal.

COLLEGES AND UNIVERSITIES RATE AGREEMENT

EIN: 1590936101A1

ORGANIZATION:
Embry-Riddle Aeronautical University
1 Aerospace Boulevard
Daytona Beach, FL 32114-3900

DATE:09/18/2020

FILING REF.: The preceding agreement was dated 01/13/2020

The rates approved in this agreement are for use on grants, contracts and other agreements with the Federal Government, subject to the conditions in Section III.

SECTION I: INDIRECT COST RATES

RATE TYPES: FIXED FINAL PROV. (PROVISIONAL) PRED. (PREDETERMINED)

	EFFECTIVE PERIOD				
TYPE	**FROM**	**TO**	**RATE(%)**	**LOCATION**	**APPLICABLE TO**
PRED.	07/01/2016	06/30/2022	43.50	On-Campus	All Programs
PRED.	07/01/2016	06/30/2022	23.00	Off-Campus	All Programs
PRED.	07/01/2016	06/30/2022	6.00	Off-Campus	(A)
PROV.	07/01/2022	Until Amended			Use same rates and conditions as those cited for fiscal year ending June 30, 2022.

*BASE

Modified total direct costs, consisting of all salaries and wages, fringe benefits, materials, supplies, services, travel and subgrants and subcontracts up to the first $25,000 of each subgrant or subcontract (regardless of the period covered by the subgrant or subcontract). Modified total direct costs shall exclude equipment, capital expenditures, charges for patient care, student tuition remission, rental costs of off-site facilities, scholarships, and fellowships as well as the portion of each subgrant and subcontract in excess of $25,000.

(A) Intergovernmental Personnel Act Agreements. All ERAU campuses.

ORGANIZATION: Embry-Riddle Aeronautical University

AGREEMENT DATE: 9/18/2020

SECTION I: FRINGE BENEFIT RATES**

TYPE	FROM	TO	RATE(%)	LOCATION	APPLICABLE TO
FIXED	7/1/2020	6/30/2021	29.10	All	Full-Time Employees
FIXED	7/1/2020	6/30/2021	8.00	All	Part-Time Employees
PROV.	7/1/2021	Until amended			Use same rates and conditions as those cited for fiscal year ending June 30, 2021.

** DESCRIPTION OF FRINGE BENEFITS RATE BASE:

Salaries and wages.

SECTION II: SPECIAL REMARKS

TREATMENT OF FRINGE BENEFITS:

The fringe benefits are charged using the rate(s) listed in the Fringe Benefits Section of this Agreement. The fringe benefits included in the rate(s) are listed below.

TREATMENT OF PAID ABSENCES

Vacation, holiday, sick leave pay and other paid absences are included in salaries and wages and are claimed on grants, contracts and other agreements as part of the normal cost for salaries and wages. Separate claims are not made for the cost of these paid absences.

OFF-CAMPUS DEFINITION: For all activities performed in facilities not owned by the institution and to which rent is directly allocated to the project(s) the off-campus rate will apply. Grants or contracts will not be subject to more than one F&A cost rate. If more than 50% of a project is performed off-campus, the off-campus rate will apply to the entire project.

Full-Time Employees fringe benefits rate includes Group Health Insurance, Retirement, Tuition Waiver Employee, Personal Leave Paid at Termination, Unemployment, Workers' Compensation, and FICA Taxes.

Part-Time Employees fringe benefits rate include Unemployment, Workers' Compensation, and FICA Taxes.

DEFINITION OF EQUIPMENT
Equipment means an article of nonexpendable tangible personal property having a useful life of more than one year, and an acquisition cost of $5,000 or more per unit.

The one year rate extension of the indirect cost rate was granted in accordance with the OMB Memorandum M-20-17.

Next F&A rates proposal based on actual costs for fiscal year ending 06/30/2021 will be due no later than 12/31/2021. Next Fringe Benefits rates proposal for fiscal year ending 06/30/2020 is due in our office by 12/31/2020.

SECTION III: GENERAL

A. LIMITATIONS:

The rates in this Agreement are subject to any statutory or administrative limitations and apply to a given grant, contract or other agreement only to the extent that funds are available. Acceptance of the rates is subject to the following conditions: (1) Only costs incurred by the organization were included in its facilities and administrative cost pools as finally accepted: such costs are legal obligations of the organization and are allowable under the governing cost principles; (2) The same costs that have been treated as facilities and administrative costs are not claimed as direct costs; (3) Similar types of costs have been accorded consistent accounting treatment; and (4) The information provided by the organization which was used to establish the rates is not later found to be materially incomplete or inaccurate by the Federal Government. In such situations the rate(s) would be subject to renegotiation at the discretion of the Federal Government.

B. ACCOUNTING CHANGES:

This Agreement is based on the accounting system purported by the organization to be in effect during the Agreement period. Changes to the method of accounting for costs which affect the amount of reimbursement resulting from the use of this Agreement require prior approval of the authorized representative of the cognizant agency. Such changes include, but are not limited to, changes in the charging of a particular type of cost from facilities and administrative to direct. Failure to obtain approval may result in cost disallowances.

C. FIXED RATES:

If a fixed rate is in this Agreement, it is based on an estimate of the costs for the period covered by the rate. When the actual costs for this period are determined, an adjustment will be made to a rate of a future year(s) to compensate for the difference between the costs used to establish the fixed rate and actual costs.

D. USE BY OTHER FEDERAL AGENCIES:

The rates in this Agreement were approved in accordance with the authority in Title 2 of the Code of Federal Regulations, Part 200 (2 CFR 200), and should be applied to grants, contracts and other agreements covered by 2 CFR 200, subject to any limitations in A above. The organization may provide copies of the Agreement to other Federal Agencies to give them early notification of the Agreement.

E. OTHER:

If any Federal contract, grant or other agreement is reimbursing facilities and administrative costs by a means other than the approved rate(s) in this Agreement, the organization should (1) credit such costs to the affected programs, and (2) apply the approved rate(s) to the appropriate base to identify the proper amount of facilities and administrative costs allocable to these programs.

BY THE INSTITUTION:

Embry-Riddle Aeronautical University

(INSTITUTION)

RdB.H

(SIGNATURE)

Randall B. Howard, PhD.

(NAME)

Senior Vice President and CFO

(TITLE)

10/06/2020

(DATE)

ON BEHALF OF THE FEDERAL GOVERNMENT:

DEPARTMENT OF HEALTH AND HUMAN SERVICES

(AGENCY)

Darryl W. Mayes -S

Digitally signed by Darryl W. Mayes -S
DN: c=US, o=U.S. Government, ou=HHS, ou=PSC, ou=People, 0.9.2342.19200300.100.1.1=2000131669, cn=Darryl W. Mayes -S
Date: 2020.10.05 10:07:25 -04'00'

(SIGNATURE)

Darryl W. Mayes

(NAME)

Deputy Director, Cost Allocation Services

(TITLE)

9/18/2020

(DATE) 2879

HHS REPRESENTATIVE: Lucy Siow

Telephone: (301) 492-4855